MAIN CURRENTS

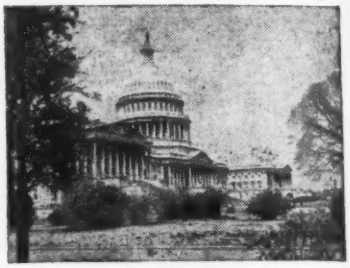
OCTOBER IN MODERN THOUGHT 1947

ANIMATO

HILLA REBAY

MAIN CURRENTS IN MODERN THOUGHT

A co-operative journal to promote the free association of those working toward the integration of all knowledge through the study of the whole of things, Nature, Man, and Society, assuming the universe to be one, dependable, intelligible, harmonious.



VOL. 5 – NO. 4 OCTOBER 1947 $3 A YEAR

"Ah, but a man's reach should exceed his grasp, or what's a heaven for?"
—BROWNING

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THE COVER OF THIS ISSUE is adorned by an example of non-objective painting by Hilla Rebay. We are indebted to the Museum of Non-Objective Painting for this as for previous examples of outstanding representatives of this movement, so generously shown by the Solomon R. Guggenheim Foundation, at the Museum in New York City. In an early issue of MAIN CURRENTS an extensive bibliography of art in its several relations to psychology, to natural laws; to logical principles, and the like, will be published. The discussions will include all aspects of modern and contemporary movements.

MAIN CURRENTS IN MODERN THOUGHT is published quarterly to call attention to significant contributions to learning currently being made by leading workers in the multiple fields into which knowledge has come to be classified. It relates these advances to each other and to the classical and contemporary views of Eastern, European and American thinkers. It is designed to save time for the reader by providing a vantage-ground from which the whole world of knowledge may be surveyed and kept in proportion as it moves toward integration. *Its editors assume that the principles of art, the universals of philosophy, the laws of Nature and Man as formulated by science, and the truths of comparative religion, can be orchestrated into a harmonic, meaningful, ethical body of teachings which can be and should be made the central core of curricular study in the educative process at all levels of development.* In condensing text, square brackets [ ] indicate editorial interpolation. Three dots . . . in the text indicates a word, phrase or passage omitted in the interest of brevity or clarity. Other usages are standard. $3.00 a year. Contributors to MAIN CURRENTS enjoy full liberty of opinion and of expression in these pages. Copyright 1947, by F. L. Kunz, Editor, Port Chester, New York, to whom all communications regarding MAIN CURRENTS IN MODERN THOUGHT should be addressed. E. B. Sellon, Associate Editor. Entered as second class matter April 13th, 1946, at the post office at Port Chester, New York, under the Act of March 3rd, 1879.

A NEW OPPORTUNITY

Editorial Announcement

The publication of this, the final number in our fifth volume, has been delayed so that we might include a formal announcement which we know will be of interest to readers of MAIN CURRENTS, many of whom have actively expressed their concern over the educational dilemma of our country and our times.

Henceforth MAIN CURRENTS will serve as the journal of the Foundation for Integrated Education, a corporate entity which is fully described in the central supplement, in a form readily detached. The Foundation indeed owes its conception in great part to the magazine's pioneering years, for during this period we sought to clarify and objectify in print those educational problems whose resolution is the purpose of the Foundation. The movement derives its main force from a general, conscious and unsatisfied need among leaders in education to acquire and pass on to students, especially in college and high school, a good philosophy of man and the universe which can arise from a concensus of enlightened opinion and a common fund of important knowledge. The requirements have been carefully examined in recent issues of MAIN CURRENTS and need no further discussion at this point.

It is, however, of prime importance to say that this journal will not narrowly serve the cause of but one organization. Any group or any individual holding educative process and intelligent philosophy in high esteem, proposing to build up such process and such philosophy by actual assemblage and ordering of materials, should find strength in these pages year by year. The Aims and simple Assumptions, parts III and IV in the Foundation Announcement, are our charter. They are broad yet precise, and worth-while labors are perfectly consonant with a program of that breadth. Great structures can and do result from bricks, stone and cement laid course by course.

The incorporation of the Foundation permits us to resume in this very issue our special task of publishing mature discussion and authoritative materials pertinent to such a philosophy, which is bound in due course to effect what Chancellor Hutchins calls the metaphysical orientation of the curriculum, in our case by methods validated by recent gains in knowledge. No doubt these can be adorned and given force by appeal to the great books of Europe. The classics of the East can also be counted upon to add penetration to the insight we all desire to possess. The sixth and subsequent volumes of MAIN CURRENTS may be expected to offer a variety of contributions to this desirable cause.

The need of a valid philosophy is as old as civilization, but recent events have given new hope to those concerned with this task today, along with a new urgency. The events on the hopeful side have been in pure science; in the matter of urgency, in applied science and in the historical and social domain. Americans were heavily involved in the recent war against indoctrinating types of government, which rested their rule on assumptions of racial and national superiority, and were led by men who did not hesitate to lie and cheat. Indoctrination is a public policy which may be embraced out of ignorance, as well as from deliberate falsehood. Confusion and fear are auxiliary causes which lead a society to rely on indoctrination.

Now there is one fundamental ignorance more devastating than any other: man's doubt as to his true nature and purpose, coupled with blindness to the meaningful nature of the universe. In this respect the American scene is sad. Here we are, with all the machinery, skills and materials needed for a happy physical existence, and all the educational resources and cultural data required to crown that physical triumph with leisure devoted to psychological and spiritual adventures in the creative life. Yet we find ourselves struggling to hold fast to some simple political liberties domestically, while we move steadily by indoctrination toward another war against indoctrinating governments. It is this undeniable circumstance which, oddly enough, makes the search for a valid philosophy the most important and urgent public problem of our times.

Men engaged in business and politics see this when they speak of our need for religion, or call this a spiritual crisis. Men with educational responsibilities realize now that a resolute stand must be taken against the fateful error of assuming that religion is a matter of heart and feeling, and that science and industry and physical life generally are matters of reason; the two being separate and even inimical moods. In education we perceive today the evil of such partitioning of campus life into classroom and extra-curricular existence, into chapel and laboratory, and endless bifurcations attendant. We know that it is a philosophical failure, the conceptual breakdown, which has stunted intelligence by exaggerating intellect at the cost of feeling, exalted science at the cost of aesthetics, love, and sentience. We know, too, that the dispelling of ignorance is not a task which can be performed by a simple flight to devotion alone, "a zeal of God, but not according to knowledge." (The phrase is from Romans, x, 2, and if it needs fortification we have the significant addition which Jesus is reported to have made to a passage in Deuteronomy vi, 5: To the direction, "Thou shalt love the Lord thy God with all thy heart, and with all thy soul", Jesus adds the instruction so pertinent for us today: "and with all thy mind," in Matthew xxii, 37. We recommend this to those sincere religious men in many walks of life who have not realized the true nature of the educational remedy for the social diseases of our day.)

Current items of news show us starkly that our fundamental problem is ignorance, ramifying out into scores of forms where we are ready to recognize it while denying it at the center. Daily our citizens are asked to stand by ideals, but the philosophy which permits them to recognize the ideal in the practice is lacking. Or, a single ideal is to be achieved without support from its fellows; freedom is to be ours, but not truth. Morals, ethics, and virtue are to be established and secured within a framework of physical philosophy, when they are not physical entities. Property is to be made secure

even if the national cause be lost, not because men prize things above people or themselves above their fellows, in every case, but because property is tangible and causes are things of an inner light. Men are expected to act upon principles, but they are ignorant of the interlocking principles involved in the event which is testing them. That these are impossible tasks is made clear day by day.

The city solicitor of the great city of Philadelphia asked the courts recently to prohibit a meeting in Independence Square called to exercise free speech, on the ground that Independence Square is a shrine to free speech, and might get damaged. The Right Reverend Bishop of Birmingham was rebuked lately by the Archbishop of Canterbury for expressing publicly his profound puzzlement about a belief in virgin birth at the human level, although among "insects reproduction from unfertilized egg cells is common." We refrain from more offensive recent examples.

The truly astonishing spectacle of the modern world is the void between ideal and practice, the dead vacuum which exists where there should be an incandescent philosophy common to most men, certainly to educated men. For the persons conspicuous in the foregoing random and recent examples are all educated and experienced, some even learned. We have not chosen instances involving selfish, calculating, fanatical, unprincipled and unlettered men. We are considering only men of good will, willing to go where principles demand they go, many quite willing to pay for a peaceful and secure world in monetary ways and by other personal sacrifices. They may all be devoted to ideals which they have acquired in common, by reason of upbringing in a society which puts notions of freedom, for instance, before all its citizens, as we do in Britain and in the United States. But they do not have in common a firm knowledge of what constitutes a human being, or what are the principles upon which the cosmos is constructed. The vast interspace between the ideal and the practice is clogged with dense fog. Vision is darkened and purpose paralyzed.

It is the conviction of some of us that by patient, stage-by-stage progress, we can assemble a very considerable body of knowledge of a conceptual character which will be meaningful in term of ideal at one extremity and of practice at the other, because the materials for a scientific cosmology are today of such a character as to allow of this. The mellowing together of modern knowledge will doubtless occur through the passage of time. But social, political, economic, and historic forces do not allow us to wait on time. We are confronted by a war imminent between two indoctrinating societies, both far on the road of enforcing security measures by police methods. It is true that American indoctrination comes least from official sources, at present, but it is none the less a powerful and dangerously growing force. Russian indoctrination is quite candidly pursued on explicit ideological grounds. The alternative for us is a free inquiry which gets us systematically somewhere, not piecemeal factualism which leaves us sprawling philosophically all over the place. We speak here of freedom under law, not freedom of randomness and chaos. We seek laws and principles at the heart of the universe, confident that man as man is near that heart, and that his inner nature and most binding being stems from the same principles and properties, and pulses on the same beat as, in lesser ways and without individual freedom, Nature around us throbs.

In sum, it is a conviction of some of us that we have not examined freely, democratically, intensively, and with intellectual honesty, that great wealth of materials which recently has made it hopeful to engage in such fundamental study. Until now no university or educational society known to us is committed to an investigation with proper equipment, staff, and resources to make a sustained effort possible. For fifteen years one after another of our great universities has proclaimed the need and there rested the case. We propose that this case be made a cause.

Does anyone deny that every day the urgency grows greater to orient ourselves, to unite all our intellectual and moral forces, to strengthen religion with science and to control and direct the results of science with moral firmness? Can such national union in purpose come about until it is experienced by enough citizens and leaders to make it a commonplace of American life? Do we not have the prodigious task of elevating the physical interpretation of the American standard of living to psychological and cultural levels? Can this work be done anywhere if it be not done first and best on our campuses, and so eventually in our high and elementary schools? Only an enriching philosophy, rational, comprehensive, democratically achieved, contemporary in reach and universal in scope, is the alternative to war, because possession of this alone gives that force and purpose to us, as a nation, which other people may feel they have achieved through official political and economic philosophy.

DOES THE UNIVERSE HAVE A MIND?

William P. Montague

From the beginning of European philosophy there have been two fundamentally opposed theories as to the nature of mind and its relations to . . . the body. The first . . . Spiritualistic Dualism . . . is the theory that the minds of men and perhaps of animals have a reality of their own . . . The second . . . Naturalistic Monism . . . is the view that mind, whether human or animal, is an inseparable aspect of the organism and its processes.

Of the many characteristics of the kind of reality that we call mind or mental, I select those four which . . . contrast most sharply with the kind of reality we call matter or material.

1. *Privacy.* Everything that is mental is "private" in the sense of not being externally observable . . .

2. *Duration.* Mental states are like material or physical events in that they succeed one another in time . . . But in a sequence of physical events the later moments must exclude the earlier, while in a sequence of mental events the later moments can include the earlier . . . Physical time has only succession, mental time has duration as well as succession . . . This duration is of two kinds. There is the primary or continuous duration, which is called the "spacious present," and there is the secondary or discontinuance duration, which is called memory . . .

3. *Purposiveness.* Anticipation of the future is the consequence of memory of the past . . . the capacity of the present to contain and to pursue an imagined future . . .

4. *Integration.* This . . . might be called "organicity" as well as "integration" . . . Not only do we assimilate into our conceptions, our purposes, and our characters the sensations that the environment presents, but we organize the environment itself . . . All the products of culture . . . are projections into the external world . . . of the mind's own structures, its hopes and fears and questionings . . .

When we turn . . . to consider the hypothesis of a cosmic mind, we are impressed with the meagerness of evidence available to support such a hypothesis . . . But . . . it is difficult not to believe that the cosmos as a whole possesses a completer unity than any of its parts, and thus constitutes an integrated field of energy having an organicity like that of mind and a memory from which nothing of the past could be lost . . . Everywhere throughout organic nature there is the sign of something like mind dimly but assuredly at work . . .

Science does, to be sure, record everyway the opposite of integrations . . . now frequently called the Increase of Entropy . . . But is it not true that this sad trend in nature must have been preceded by an opposite trend, which we can call anti-entropy? . . . This suggests a hypothesis . . . that the anti-entropic power that must exist in nature is a mental power akin to what we find in ourselves . . . not an omnipotent power . . . but . . . the tendency to higher organization and harmony . . .

Cosmic evolution could then be regarded as the work of organizing the independent centers of activity in the divine mind that constitute its contents taken distributively and as a plurality, and informing them more and more with the harmony characteristic of that mind when considered in its collective unity. (Abstracted from *The Saturday Review of Literature*, September 6, 1947).

MUSIC, MATHEMATICS, AND COSMOLOGY

Oliver L. Reiser

I. The Mathematics of Beauty

The doctrine that the structural framework of our universe represents a kind of frozen music, that in general there is a common substructure for music and cosmology, is a theory that long has gripped the minds of imaginative poets and philosophers. And indeed there is much to recommend this view; so much, in fact, that in the present article my avowed purpose is to pass from the realm of the tangible and material into the domain of abstract being to isolate some of the unwritten music underlying the grosser form of nature and glimpse its possible significance.

The notion that nature is constructed according to an architectonic which is exemplified in both music and mathematics was first enunciated in Western thought by Pythagoras. The ancient Greek mathematician, philosopher, astronomer, and founder of a school of mysticism, saw in number patterns and geometrical ratios the explanation of all natural phenomena. He made discoveries concerning the mathematical basis of musical harmony, and in fact invented the musical scale which was to evolve into the generally accepted European scale for music. It is not surprising, therefore, that the man who first discovered the relation between the lengths of vibrating strings and the corresponding tones they give off should also hit upon the idea that the stars and planets, like vibrating bodies, should give off musical notes, thus producing the beautiful even if humanly inaudible "music of the spheres." Thus the morning stars sing together and the origin of harmony is in divinity.

This ancient Greek speculation has had a long and fascinating history. Pythagorean mysticism became the prototype for later variants of the doctrine that "God geometrizes," and the results of this divine harmony, it was believed, could be discerned in the book of nature, written in mathematical symbolism. Quite properly, therefore, Kepler exclaimed after discovering the three laws of planetary motion, "Oh Lord, I think Thy thoughts after Thee!"

One interesting feature of the record of speculation is the persistence of the Pythagorean thesis concerning the half-revealed meaning of mathematics in music and art. The idea which Pythagoras and Plato first enunciated in philosophical form has been carried into more elaborate exposition in the work of such moderns as Jay Hambidge in his studies on *Dynamic Symmetry,* where it is shown how certain types of rectangles form the basis of Egyptian and Greek design, and the research of George D. Birkhoff, late Harvard mathematician, whose book on *Aesthetic Measure* reveals the elementary geometrical forms which underlie ornamental designs and vase forms. In this connection, one thinks also of Prince Ghyka's unique studies.

As a further example of the possibilities of the mathematical analysis of beauty, consider the role of the spiral

in nature. In his engaging studies of spirals and their exemplifications in nature Sir D'Arcy Thompson, in his monumental book *On Growth and Form* (Chapter XI), describes the several kinds of spirals as they exhibit themselves in real forms. He defines a spiral as a curve which, starting at a point of origin, continually increases its radius of curvature as it recedes from that point. On a broader canvas, Dr. Harlow Shapley has indicated how the dynamic spiral appears quite universally, "from spiral nebula to spiral motions of electrons and other charged particles in the sunspots;" and he adds that "the spirals of conchology and of plant stems, of the fine arts, and the terrestrial tornadoes, find counterparts in the astronomical field." As he notes, the logarithmic spiral is connected with the mathematical definition of electrical phenomena as well as the energy we describe as life and growth.

Considering all this evidence as confirmation of the proposition that geometry, number, and other mathematical properties are the very root of every kind of formal beauty, it appears reasonable to conclude that the scaffolding which guides the artist in his creative work is indeed such deep-lying components as symmetry, order, relation, harmony, and the like. And this is all very acceptable to the aesthetician and gratifying to the mathematician. But where does it leave the philosopher, whose concern is with the more fundamental question of the relation of mathematics to nature and to man's mind? Granted that beauty exists somewhere, subjectively in man or objectively in nature, does the applicability of the techniques and the language of mathematics to the art-object in any way validate by modern tests the ancient realism of Plato and Pythagoras? Is there a real domain common to both nature and to man?

The answer I shall give to these questions is in the affirmative. It is perfectly feasible, using contemporary data, to extend our conception of the universe to include the Supreme Architect of Plato and Jeans as the geometer who functions through the properties of a real Space-Time Matrix or Cosmic Energy Continuum to create — give emergent being to — the forms of matter, life, and mind. As we have indicated in our previous book, *The World Sensorium,* the mathematics necessary to this new synthesis is spherical harmonics, which unites the laws of musical harmony with those of electricity and the flow of heat. For this direction in my thinking I am indebted to documentation gathered by Mr. F. L. Kunz. Reference to this material here, however, is my own terminology, and necessarily glancing.

This approach yields quite a different conception of the nature and function of the arts than that provided by the Freudians. The arts are not an escape from reality; nor even merely a sublimation of instinctive urges. The *arts of space* — architecture, sculpture, and the rest — and the *arts of time* — music, dance, and so forth — are not to be treated from the inner point of view as but subjective forms of human experience. Rather, the mind responds to the language of beauty because mind is itself a manifestation of the symmetrical patterns of space and the rhythmical patterns of time which constitute the music of human consciousness. If this subjective order of space-time is in any manner an epitome of cosmic harmony, then Pythagoras was right in principle when he proposed a wider objective significance for his number patterns. Nature answers to the structure of man's mind, and mind exemplifies the laws of nature, because nature and mind share a common structure, which is the structure of mathematical logic — more fundamental even than the traditional Aristotelian principles of thought and the Euclidian axioms of geometry.

From our point of view, the relativity (multiplicity) of alternate mathematical systems does not destroy the validity in the conception of an absolute language (a meta-language) for nature; and the variability of art standards (e.g., for tonal combinations) does not invalidate the belief in an absolute set of values for aesthetics. The "relativity" of truth and beauty may only indicate that we do not yet possess the absolute language of science and art towards which we are moving. When we get to that final goal, if we ever do, we may find that the language of "truth" and the language of "beauty" are one and the same.

It is not possible here to demonstrate this proposition in detail. But in order to show the fertility of the approach, I shall apply the formulation to one type of illustration — the emergence of wave motions on certain levels of nature. I begin with what might be called the dilemma of science.

II. The Dilemma of Science

One of the striking features about the development of the sciences is the accelerated accumulation of masses of detailed facts. Along with this has gone an increasing difficulty in synthesizing these facts into meaningful systems of knowledge. In view of this fact that science does not seem to be making progress toward complete and ultimate explanation, those of us who are interested in scientific synthesis may well ask, what is to be done?

As a possible method of integrating the vast masses of facts of science into meaningful wholes, the adoption of a "phenomenological" viewpoint in science may be advocated. By phenomenology is meant the study of that which *exhibits* itself: it is the *descriptive* point of view obtained by viewing a thing *as a whole.* A phenomenological presentation is a pattern given in perception, appreciated as a totality.

For science magnification of microscopic details creates problems for understanding. It is literally true that we can no longer see the forest for the trees. I therefore suggest that we occasionally ascend in balloons and view the forest and ignore the trees. I suppose a psychiatrist would describe this as a "flight from reality"; but it is interesting to note that scientists sometimes turn to this viewpoint. For example, physical chemistry, in employing the second law of thermodynamics, is resorting to the phenomenological approach. And this is also the essence of gestalt theory.

Another illustration of the phenomenological method is found in botany. We may view a flower as a phenomenological pattern, the attitude of appreciation; or like the biochemist, who studies the intimate mechanisms, we may analyze the petals of the flowers into their intri-

cate molecular structures. But in the latter case we must not forget that the flower, in spite of its detailed complexity, possesses a *phenomenal simplicity* which is responsible for its *beauty* for us. Perhaps this is what J. B. S. Haldane had in mind when he pointed out that "To my mind the closest analogy to the evolution of a given group (of animals) is the history of the art and literature of a civilization." This puts biological evolution on the level of an artistic production and makes nature the great improvisor of aesthetic productions.

If we thus view the productions of nature as works of art, the pleasant task of the poet and the philosopher is that of enjoying the harmonies and melodies of nature's music, leaving to the scientist the study of the basilar membrane processes and the cortical functions (or the optic retina and the visual cortex, if we shift the experience to seeing); to the acoustical expert the study of the objective sound waves; and to the mathematician the discovery of the numerical values of the components of the corresponding Fourier's series.

III. Wave Motions and Emergence

As an example of phenomenological emergence, consider the case of a water wave. Even though water as a "fluid" is composed of discrete molecules (hydrogen and oxygen), we apply a mathematics of continuous quantities (the differential equations of hydrodynamics) to the behavior of the medium. The wave we see moving over the surface of the water is composed of H_2O molecules that move in but one direction — up and down — *and yet the crest of the wave moves forward in a new direction* (*dimension*), *horizontally*. In all similar cases of emergence, we suppose that each rhythm represents the averaging effect of a statistical ensemble, because the field-forces (in the above case of the water wave these are molecular fields) are integrated to produce a macroscopic rhythm. In the mathematical handling of these situations we need what is known as the Laplace equation. The most important partial differential equation is:

(1)

$$\frac{\delta^2\phi}{\delta x^2} + \frac{\delta^2\phi}{\delta y^2} = 0$$

This is known as Laplace's equation. The applications embrace gravitation, electricity, magnetism, hydrodynamics, conformal mapping, conduction of heat, stream lines, isothermal families, and so forth. In special cases, the results will look like the globe's lines of lattitude and longitude, that is, symmetrical patterns spreading out in space and time. In the three dimensional cases the corresponding equation is:

(2)

$$\frac{\delta^2\phi}{\delta x^2} + \frac{\delta\phi}{\delta y^2} + \frac{\delta^2\phi}{\delta z^2} = 0$$

The physicists tell us that the differential equation for the steady flow of heat, light, electric waves, and magnetism, where we introduce a as the velocity of transmission, is this:

(3)

$$\frac{\delta^2 y}{\delta t^2} - a^2 \frac{\delta^2 y}{\delta x^2} = 0$$

This equation expresses the *orderly* displacement in space, progressing along the time-axis. In all such cases, when the properties of a given differential equation are developed, the results are applicable to heat, light, and so forth, where there is a continuous spreading out of the wave from its source.

In our illustration of the water wave, we see how a large number of discrete elements in an averaged state produce a *plenum* or *medium* — water — with its wave motions as the example of *emergence*. But the same result appears in other media, air for example, where wave trains (undulations) travel through space. In the case of *air*, we see again the averaging process whereby a seeming continuity, requiring a *field-plenum* dynamics, is produced from the statistical behavior of discrete units. Air is treated as a *continuum* because it transmits sound waves. And yet we know that more detailed analysis of this *elastic medium* shows that it, too, is composed of particles. In both cases, air and water, no difference can be observed between the superficially observed *surface effects* and the behavior predicted on the basis of a mathematics of continuous quantities (the infinitesimal calculus).

This process whereby particles-in-interaction produce continua in which wave motions are possible is tremendously significant. In such cases a large number of discontinuous (corpuscular) elements in an averaged state produce a seeming plenum, the mathematical description of which requires a dynamics of the continuous (hydrodynamics). Is it possible that the remarkable properties of all emergents on all levels arise in the same way in which the novel properties of water arise? If so, the historically new dimension of growth and evolution is the $n + 1$ dimension, where n is any lower spatial aspect of "material" elements ("particles") out of which the higher organization emerges.

These cases of phenomenally emergent patterns are examples of inferior random forces yielding their freedom of motion to a higher order of simplicity. The conception that emergence can occur along many dimensions (what emerge are the phenomena, not the dimensions) in historically new organizations deposited by the forward sequence of time has the merit that, on all levels, it satisfies the two requirements of a theory of progress — individual and social — which are (1) *freedom*, and (2) *self-discipline*. For example, in the spiral action of time, previously mentioned in connection with growth, there is a movement into a new dimension, and this illustrates *freedom*, but this forward sequence is not haphazard but controlled (*disciplined*) by conformity with that part of the past which can produce the best future, i.e., which makes Korzybskian time-binding possible. In other words, the time-line of phenomenal emergence would not be a spiral if there were no continuity of this special sort with the past — it would be a different sort of line.

IV. Isomorphism and Dimensionality

Our concept of the historically new emergence dimension was deliberately framed to provide a reconciliation of the *relativity* of motion with the *absolutivity* of motion. The type of motion in which mechanics is primarily interested is subject to the principles of relativity (though it must not be overlooked that the case for rotational motion is still controversial); but *growth*, a type of change and therefore motion in which physics is not concerned (except in atomic and stellar evolution), is *not* relative. It is a type of motion—change toward increasing complexity of parts and integration of function — to which Einsteinian relativity does not apply.

Motion as it is represented by the fourth coordinate of the space-time continuum is relative; but evolution calls for extra dimensions of time, new forms of spatio-temporal organization of the previously evolved parts. This historically new dimension of growth (a fifth dimension required to explain growth and sentience for plants and animals, if we may over-condense Kunz's suggestion) is for us the $n + 1$ dimension, where n is any lower "spatial" dimension of "materiality" out of which the higher temporal organization is to emerge.

It is this property of phenomenal emergence of turning time (function) into space (structure), by congealing the products of evolution into the "matter" of the next higher level, which has made it possible for nature to pass from *atoms*→*molecules*→*living cells*. The next step in organismic development will perhaps be the emergence of a world psychosomatic entity, but this will bring even higher dimensions into manifestation. Here the applications of spherical harmonics to include psychological and social phenomena will be in order. But, as before, we shall still be concerned with tracing the manner in which functions are spread over spherical (advancing) surfaces — in this case the plenum of a psycho-social field. Here again, following Mr. Kunz, we predict that this method will continue not only to have its present wide applications in electricity, and the rest, but also have applications in the handling of electromagnetic forces at work in biological and psychological domains.

In this manner we begin to make good on our earlier promise to find a language which can be put on an all-world basis for invariant transfer across social wholes. It is a curious fact that mathematical symbolism and musical scoring are the only international "languages" that Western civilization has thus far developed, *and this suggests that perhaps music and mathematics promise better than any other media to satisfy the requirements of a universal language*. This is especially important if the object of scientific investigation — the *Cosmos* — and the field of aesthetic and emotional perception — *Music* — both turn out to be applications of the more fundamental science of mathematical logic, the study of abstract and universal order systems. One of the most fundamental examples of such order-systems is displayed by the *isomorphic structures* exemplified by spherical harmonics in its various applications, previously mentioned; and thus we find that the subject which in the days of the ancient Greeks was incarnated in what Pythagoras called the "music of the spheres" now comes into its own, and the full circle of development is complete!

We see, therefore, that music and mathematics turn out to be the experiential substance and intellectual form of consciousness. As such, they correspond to the *aesthetic component* and the *theoretic component* of Professor Northrop's duality. Together they provide the basis for the "meeting of East and West" which the synthesis of inner experience and objective science will make possible. Such discoveries of the *universals* of philosophy advance the cause of intellectual and social synthesis, and confirm the surmise of Mr. Kunz concerning the analogies of Oriental and Occidental thought. If it is true that *Maya* of India is *electrons* in Western science, *Akasha-Kala* is *space-time*, in a manner which unites East and West, ancient and modern, then indeed the goal of the integration of all knowledge becomes attainable in real fact. Already in music and mathematics, then, we have two languages — emotional and intellectual — which, between them, may provide the basis for further developments in human communication and understanding. In this manner we come upon the forerunners of an invariant symbolism which should provide us with maximum freedom from special linguistic frameworks, so that we may rise above the mental shackles of elementalistic frames of reference of races, nations, religions, and the like, and in due time create the higher mental-verbal world of a universal, planetary civilization.

ART AS VIBRATIONAL PATTERN

Fredericka Blankner

"A New Method of Education for the Composer based on a New Psychology of the Arts," by Dr. Frederika Blankner (Adelphi College) appears in the current autumn number of *Musicology* (Middlebury, Vermont). The author here extends to music a series of some dozen studies published to date through the American Association for the Advancement of Science, the Modern Language Association of America, and other learned societies, and variously issued. We draw upon the appended bibliography in order to describe the proposal in the author's own terms.

Dr. Blankner aims at the unfolding of a new psychology of the arts and a new orientation for art method, education and criticism derived therefrom. Her concern is with the "inviolables" of art, those basic principles conditioning art-forms *a priori*, the definition of which necessarily antecedes consideration of other factors in art such as the creative and apparently free powers of the artist.

The starting point for Dr. Blankner is vibration design. She has expanded familiar node-forms into a working hypothesis for new and broader frameworks of thinking, in which art, science and ethics are to be

united. The experimental basis for the theory is the laboratory demonstration of figures that are formed when uniformly distributed sand is set into motion on a metal plate oscillated by rubbing a violin bow along its edge. The vibrations cause the sand to dance above the plate and settle into regular geometric patterns, called "Chladni figures" after their eighteenth century discoverer. The sand moves away from the areas of greatest motion (antinodes) to areas where there is little or no motion (nodes).

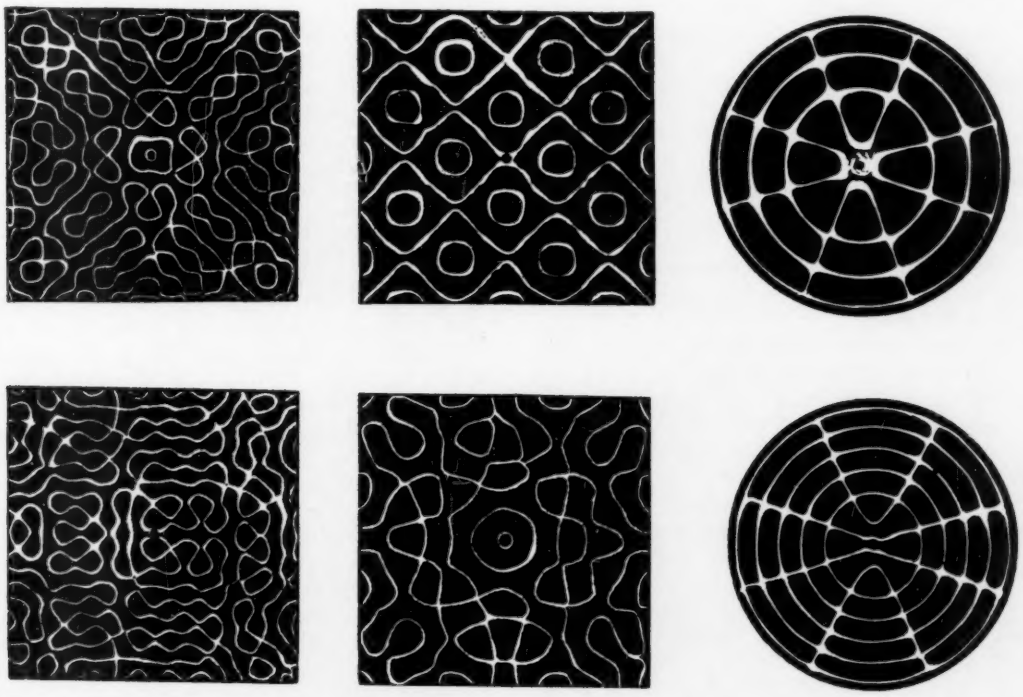
Of this phenomenon of vibration, and the laws implied therein, Dr. Blankner observes in one of the series of papers, "all things capable of study in the laboratory to date have been found to be vibratory in their atomic construction and often otherwise, however non-vibratory in appearance, thus confirming the original intuition of Heraclitus that 'all things flow'."

The question for the artist is how he shall conceive of this process in relation to human mind. Dr. Blankner suggests that the artist's mind may "correspond with the Chladni plate; his inspiration to the oscillator inducing the vibration; and his medium to the grains of sand." Just "as the Chladni figure is the graph of the vibration producing it, so . . . the art-form is seen to be the graph of the mind of the artist during the period of creation or inspiration." Following this explanation through, poetry is defined as "prose at a higher spiritual temperature."

The application of any theory to the psychology of art creation is necessarily less demonstrable than in more concrete fields of study. But since Dr. Blankner is established as a creative worker in poetry, she has been able to develop and check her theory throughout in the light of her own experience. The theory has been evaluated widely also through discussion with artists and creative workers in various aspects of life. Among those who have found it of much interest are Thomas Mann, Aldous Huxley, Lord Dunsany, J. B. Priestley, Gerald Heard, Claude Bragdon, Boris Blai, Dudley Crafts Watson in the arts; and in other fields, Sir Hubert Wilkins, J. Paul Visscher, John J. O'Neill, Robert Maynard Hutchins, Henry Goddard Leach, Paul Radosavlkevich, and Edgar Goodspeed.

Since the mind of the artist (as well as of all other persons) is part of the social evolution of the whole of man, and thus in his art-form produces for us a "microcosmic pattern or graph" of what Dr. Blankner calls his "social moment," the harmonic theory must have social meanings. And since the mind of the artist is the most sensitive and therefore the first to react to social influences, the author finds in "art . . . a barometer of history."

From such application of this theory to social evolution it is but a step to the realization that "we may be able to induce the pattern for a stable world in the same deliberate and scientific way in which we produce a har-



CHLADNI FIGURES

Photographs of Chladni figures produced by Professor R. C. Colwell, Head of the Physics Department, West Virginia University, and used by his permission. The white lines indicate the grains that have gathered at the nodes of vibration.

monious Chladni figure in the laboratory." Dr. Blankner believes "the pattern for permanent peace may be revealed to men when they cease combat in their international councils long enough to achieve the conditions of quiet, poise and tone necessary for its formation, and when they submit, at the same time, to the 'vibration' of cooperation. The achievement of peace may thus lie in the field of what we might call the combined art-physics-ethics of international relations."

It is an interesting fact, in this connection, that two distinguished war exiles, Dr. Milos Safranek and Bonislav Martinu, now connected with the Czech government, perceived the pressing necessity of recognizing cultural needs and specifically aesthetic standards as being just as important for the redemption of Europe as political, economic or direct social action. In Washington there is talk of a cabinet secretary for education, security, and the like.

In its application to the biological and physical domains, this theory is of special interest. The instinctive response of animals to their environment on a lower level, and the operation of insight in man on a higher are here accounted to be a juxtaposition of concepts, corresponding to a juxtaposition of grains on the Chladni plate. Through such vibrational harmony man is able to perceive whole situations and comprehend abstractions. About this the author says, "What we call 'instinct' or 'hunch' or the action of 'attraction' may be the urge of the vibration induced by our need in order to shift us to the proper position or action necessary to satisfy it. We and the ideas or things we require seem to be coaxed into juxtaposition in exactly the same way that the grains of sand are pushed by the vibration in the metal plate."

Speaking further regarding the insight of inspirations, Dr. Blankner observes: "It is clear that if the artist wishes to be a worthy instrument for the generation or reception of the highest inspiration and for the expression thereof, his greatest possible spiritual development is necessary. When his own vibration has become truly exalted and refined, it is then that he can harmonize sufficiently with the cosmos to generate or receive inspirations for great symphonies and masses."

Regarding the art of the future, the author feels that "the growing dynamic quality in art, illustrated by Futurism, aeropainting, sculpture with moving parts and the like, indicates that the art of the future will become more and more dynamic until it is satisfied with the only truly dynamic material, life itself."

From this, Dr. Blankner is led to her conclusion that in the art of the future philosophy, science and ethics will combine with life itself. "To achieve the goal in life and art that the human race is seeking, all the arts and sciences must cooperate with ethics to determine what the perfect pattern for mankind is, and then they must consciously unite to bring it into being. Any attempt to work out the future through any one or two alone is like trying to make a tripod stand erect on only one or two of its legs."

Whatever opinion may be as to the extent to which this theory is immediately applicable, the argument itself is arresting. Other papers in the series are forthcoming, especially in the psychology of the arts, where Dr. Blankner has worked out her theory most completely. Particularly in this field it should have influence and value in a new orientation of art methods and art education.

We therefore take the opportunity to add a bibliography of the several papers by Dr. Blankner and others, mainly devoted to a wide variety of applications of the theory, from which sources the foregoing description has been drawn. This list of sources will serve to bring the account of the concept fully up to date. We do not here include reference to the author's extensive and well-known poetical writings.

I. Basic initial papers: 1. "Art, man and the cosmos as vibration design," Modern Language Association of America, Harvard University, December, 1940. Review by John J. O'Neill in the *New York Herald Tribune*, January 5, 1941, Section II, p. 5. 2. "A new psychology of the arts: a theory offering a new explanation of the psychological process of creative activity and of the nature of art, uniting the arts and sciences in a joint field of physics, aesthetics and psychology; together with a statement of the natural laws governing such process and a new orientation for art method, education and criticism derived therefrom," the American Association for the Advancement of Science, Dallas, Texas, December, 1941. Forthcoming in the *Journal of General Psychology*.

II. Papers applying the principles concerned to various fields: A. To the arts and sciences in general: 3 . "The unity of art with science — inquiry into new fields: the physics of aesthetics and the aesthetics of physics," the Modern Language Association of America, Indianapolis, December, 1941. B. To the arts in general: 4. "Art is a wave." Forthcoming. C. To literature: 5. "Literary pattern as a graph of social evolution, an inquiry into a new field," the Modern Language Association of America, New York City, 1944; published in the symposium volume, *Twentieth Century English*, Philosophical Library, New York, 1946; reprinted in the *Humanities Review* (San Antonio, Texas), January, 1947, and in *Mind Digest*, January, 1947. 6. "The vocabulary of James Joyce's *Finnegans wake*, its causes and significance — a study in comparative literature, arts and society," the Modern Language Association of America, Indianapolis, December, 1941; 7. "A new explanation of the structural characteristics of classical literature," the American Philological Association, Hunter College, January, 1943; 8. "Literature, too, splits and builds the atom — a study in comparative arts, science and society, entering a new field, the physics of literature and the arts." Forthcoming. D. To music: 9. "A new method for the composer based on a new psychology of the arts," *Musicology*, Autumn, 1947, Vol. I, no. 4, pp. 399-406. E. To world organization: 10. "A new explanation of the interrelation between man's mind and the structure of civilization with application to a successful pattern for world organization." Forthcoming. F. To the formation of the cosmos and the heavenly bodies: 11. "New working hypothesis for the formation, structure and motions of the earth," *Bulletin of the Geological Society of America*, December 1, 1942, LIII, 12, part 2, Abstracts of Section E (Geology) of the American Association for the Advancement of Science, pp. 1845-46.

THE FOUNDATION FOR INTEGRATED EDUCATION, Incorporated

ANNOUNCEMENT

I *A New Teaching Mission*

The Foundation for Integrated Education is incorporated as an educational body and approved by the Department of Education of the State of New York.

The Foundation's special function among other educational institutions and associations is to concentrate attention upon the manifest, urgent and admitted duty in our times to develop a valid conceptual background for accumulated knowledge, so that ethical, political, economic and social strengthening may result.

We use the term *concept* to mean the product of that mental gift, peculiar to mankind, which permits us to recognize the attributes common to many entities. We are thus able to detect meaning and system, and to express this as harmonious relations. Since the freedom mankind enjoys depends in an important way upon this ability to classify and hence alter environment, both physical and psychological, it follows that the development of conceptual skills is of prime importance in a liberal education. If the student is to learn to stand alone, exercise his freedom, and enjoy his dignity, how is he to act except upon principle? Inherent in concepts, therefore, are all our hopes to confirm and enlarge freedom through education.

That the effective organization of liberal education upon such good terms will benefit us nationally follows directly. Confusion, fear, and insecurity are widespread, and what constitutes wise conduct in today's complex society is uncertain. Good will is by no means enough in itself to result in ethical action. Once the true character of man's constitution and his relation to nature are better understood and taught in a general educational movement democratically achieved, and his dignity and personal responsibility are restored as intelligible doctrines related to over-all principles, the young citizen—acting with his fellowmen upon principles universally conceded and confirmed by a conceptual education experienced in common—can and will enter economic, political, and social existence knowing how to do that which he knows it is right to do.

The Foundation is officially concerned only with its educational responsibilities. Its effect upon other institutions of human society is determined solely by the enlightenment it may help to bring to our confused age through that ordering of knowledge which is so long overdue.

Scholars participating in the work of the Foundation are not bound by the studies conducted, supervised, or published under its auspices, although the development of all methods, studies, and concepts will be governed by the Council of the Foundation. Official descriptions of the organization and aims of the Foundation published below (Aims and Assumptions, titles III and IV, below) and as amended from time to time, may alone be taken as receiving concurrence of participants. Since descriptions of aims and assumptions must necessarily be in such general terms as will fit the broad intent of many colleges, it may be desirable to provide a preliminary discussion of the motives of the incorporators, as one element in the whole movement.

II *Our Immediate Opportunity*

The Foundation comes into existence because its organizers have been convinced by experience that general concepts can be validated today by exact and acceptable techniques, such as have been outlined in earlier pages of MAIN CURRENTS, and by other methods, to be diligently sought.

Socially useful concepts are commonly possible if rational, aesthetic, valued, and experimental elements *be shared widely in educational experience.* The projects of the Foundation therefore include special studies and general dissemination of the principles of the arts, the universals of philosophy, the values of comparative religion, and the laws of nature as formulated in the sciences.

There is nothing novel in such studies, but the Foundation may be expected to do thorough work in the field, and it will have a special modern advantage. The actual materials of contemporary art, the demands made upon philosophy today, the present status of the religions fraternally and internally, and the new scope of science are all subject to remarkable circumstances not hitherto present. Thorough re-valuations are forced upon us by such notions as space-time, field studies in physics and biology and psychology, psychosomatics, general semantics and many other gains, and this host of developments simultaneously presses upon us imperatively *the sense of an immanent whole* framing each phenomenon. The new world of thought is thus great in significance and promise, as contrasted with European learning up to the eighteen-nineties, much as the round earth of the sixteenth century was large and liberative to the fifteenth century man with flat-earth ideas.

The foregoing considerations show that the work of the Foundation is not likely to be repetitious, artificial, or merely a skillful improvisation of descriptive surveys, however general its purposes may seem to be. Today precise methods and rigorous techniques can be applied to comprehend all knowledge and experience, and hence we may reasonably expect correspondingly firm and highly significant concepts to emerge. This prospect of gaining exact, authoritative, and stimulating results may properly be kept in mind while reading the following agreed-upon Aims and Assumptions.

III *Statement of Aims*

To collect, create and distribute authoritative instructional materials which will encourage the develop-

ment of unified over-all concepts in education; to improve the balance of relationships between the physical sciences and the social sciences; to inquire into the phenomena of purposive activity in nature, man, and the universe.

To assist teachers to understand and use such materials, and to develop an active, realistic, comprehensive philosophy which will communicate to their students the unity, coherence, and beauty of the world in which we live.

To remedy, solely by such educative measures, the conceptual and hence the ethical, social, economic and political breakdown of our times, looking to a peaceful world order.

IV *Some Assumptions*

The terms *education* and *teaching* are here interpreted broadly to apply to all aspects of the learning process, although emphasis is put initially upon this experience in school and college.

The Foundation is primarily concerned with gathering and making available required source data, illustrations, principles and the like, which will ordinarily receive general assent as valid and important, and essential to a useful philosophy of the good life.

In consonance with this function, the methods of the measurement sciences will be employed wherever possible, and their content, the laws and orders of nature, will be a conspicuous feature of the source of materials.

The specialties of religion, art and philosophy are not less realistic, each in its own way, and their verities, principles and universals will be identified.

The Foundation will not have to repeat those works which are the duty of scholars and associations of science, art, religion and philosophy, but will usually draw from them the materials for a common intellectual, experiential and verbal discourse, which, over a period of time, can form a philosophy for a truly American culture, and an American ideology to contribute to the achievement of a peaceful world.

As the Foundation is concerned with source materials, and is not responsible for the formation of any doctrines, arbitration of opinion is expected to be a minor feature of its work. That is, the Foundation, in consonance with freedom, will gather and disseminate well-founded studies which have conceptual significance, leaving to the individual the shaping of such material into his own life and thought.

It will, however, be readily understood that the work of the Foundation will imply a special interest in *order,* in all its aspects, since concepts, classification, paradigms and the like depend upon ordering.

It is also inevitable that studies of religion will be done at the comparative level, and lead eventually to a kind of normative structure which will receive assent as a high outworking of principles seen in part at other levels.

In the same way, the principles of the arts and the universals of philosophy will be conspicuous, since these bring the arts and philosophies together and make possible not only their mutuality but their consonance with science and religion.

It is also evident that since these cultural moods have their source (whatever their primal origin) in human nature, and seem to advance through exercise of freedom and originality, the study of man and his nature will be a vital element in the program of the Foundation. Into this aspect of the work ahead all other findings will enter in a new and effective way.

The eventual results of such studies will be a better understanding of the common inherence of nature and of man in the universe, and hence we may expect to vitalize a synoptic view of cosmos.

The studies projected will take a special advantage of recent advances in electronic physics, resonance chemistry, mathematical astronomy, systematic geology, reinterpretations of crystallography, genetics and symbiosis and taxonomy and much else in biology, all forms of psychology, new techniques in mathematics, semantics and harmonics, and all other fields.

But as man has been projecting his powers in art, philosophy, religion and science out into family, economic, social and political life for ages, the records of history, archaeology, anthropology and mythology contain a great wealth of expression which cannot be supplanted, however richly supplemented, by recent theory.

And besides both of these results of evolution to date (historical gains and recent theory), there is the yet unexpressed potential or the unemerged future to concern us, and this is a practical way. For if we discover pattern out of the past we shall be able to project in some measure the shape of things to come.

The Foundation has no official concern with partisan political, economic, social or domestic causes. It is engaged solely in the search for truth, great truth. Its work can reasonably be expected to have effect upon all life and human activity, since the discovery, and especially the conscious use, of law is the determinant of freedom as a practical affair; and there are laws and orders in all fields of human endeavor which, known and used, will confirm and enlarge freedom. In that sense, and in that fundamental sense, alone, the work of the Foundation may have powerful, beneficial, and could even have dramatically rapid effect upon family life, the community, the state, and world society.

V *Structure of the Foundation*

The Foundation will be governed by a Council of scholars. Its sponsors, advisors, and active participants are being drawn from learned institutions in all parts of the world, but initially in the main in the United States. The Council will act in the interests of that much larger list of sponsors and citizens generally feeling the demands of our times. Hence its work is not confined to academies. Yet, as the tasks of the Foundation are educational in character, the responsibility for making policy and guiding studies must and shall be vested in experienced educators.

In order to ensure continuity of activity, the Council will delegate the execution of its approved program to an executive group, which will implement the studies and supervise the publications of the Foundation. A director, assistant director and other consultant and staff officers will carry out these duties.

The Council and executive officers will receive frequent assistance and guidance on the practical side from the Board of Directors of the Foundation, in charge of the conservation and enlargement of the Foundation's resources.

The provisional executive group (see below) has undertaken the arduous duty of amassing a sufficient working fund, establishing an office, and making available the necessary staff, so that the Council, when called together, will have ready at hand a working instrument with which to attack the truly formidable task which is before us.

Associated with the foregoing will be special public relations counsel, determined by the peculiar purposes and needs of the Foundation. As an educational body, its work may be expected to have immediate use to institutions of learning. As an institution stimulating thought and especially conceptual thinking, the Foundation may be expected also to have marked influence upon national affairs, by means of the mere cogency of its publications. The public relations duties are therefore of a special character, and have a peculiar importance.

No less important is the role of treasurer. The tasks of the Foundation are prodigious, and the time and funds required to make the gains contemplated must necessarily be large. In truth, the work is in need of unlimited funds. The treasurer will be expected to take an active part in the shaping of the course of events under the policy laid down by the Council.

The usefulness of the studies which the Council will guide may be expected to be seen in three special fields, and for each of these a full-time counsellor is contemplated.

Centrally, the effect of the Foundation will be directed to the curriculum and the methods of education required to make the new material useful. For this purpose a curriculum counsellor will function.

Another result will be seen in the life of communities. As the studies of the Foundation begin to have effect, first in colleges and then in schools, they will necessarily prove stimulating to parents and citizens generally. Schools, in fact, will become increasingly useful as centers for adult education, and as community centers for cultural purposes. The Foundation, through its community counsellor, may be expected to be helpful along such lines.

A third consequence of primary importance may be expected in connection with commerce and industry. Everyone is aware of the effect of universal literacy upon the mass-production potential. American production would have been impossible on the recent scale seen during the war had not a certain general level of education been nearly universally available. It should be equally clear that any achievement of a general advance into a better conceptual atmosphere is bound to affect for the better the whole production complex. To assist in this area, a counsellor for commerce and industry will be important.

VI *Present and Future Services*

In order to make the assistance of the Foundation available as promptly as possible, the provisional executive is arranging for visits with special committees for integration and with faculties as a whole, first upon campuses and with associates already actively collaborating with the Foundation. The visits give opportunity to discuss techniques and possibilities. Where circumstances allow, instructional materials precisely pertinent to the methods mentioned in foregoing paragraphs may be shown. The materials constitute a promising beginning of a Survey of Knowledge in visual form. By these means, progress becomes possible from the beginning.

The initial intent is that faculty members, and especially curriculum committees, shall be convinced that systematic work and steady progress is possible, resulting in exact conceptual gains to be incorporated in faculty planning of courses of study. The visitor from Foundation Headquarters is not at present concerned with setting up a course of study for undergraduates, but participation of students of senior intelligence is stimulating. An address to the student body also proves to have orientation value.

MAIN CURRENTS serves, and is expected to continue to serve, as the regular means of communication for the Foundation.

In due time, courses of study will be offered to teachers, at first in New York City and during summer sessions at appropriate points. The Foundation serves as liaison for cultural centers of arts and learning, and advantage will be taken of these connections to make new materials available in advance of general publication.

The Foundation will make a library appropriate to its purposes, and special instructional materials, available in New York City.

After suitable consultation, and under guidance of the Council, special studies will be projected in order to fill, with data, significant gaps in contemporary knowledge which have contributed to the conceptual breakdown. Even to identify gaps will be useful. These projects will be supported with Foundation funds upon suitable campuses co-operating with the Foundation in the Survey. Similar arrangements will be made for projects in educational methods, experimenting in the teaching of concepts which can be fully possessed by faculty members and effectively communicated to students as a natural part of diversified subjects. These projects will be contrived and conducted in every instance under the general direction of the Foundation's governing body, and guided by its executive in an atmosphere of completely free inquiry. The Foundation has no formal doctrines to advocate, but is committed solely to the elucidation of generally acceptable principles, laws and concepts.

The Foundation will serve as a clearing house for institutions of learning which have come to be concerned with progress along these lines. It will be a center where reliable information can be obtained by other agencies of public information.

The Foundation will aid the cultural purposes of the UNO and UNESCO, by special activities, tours, exchanges of visitors, directed along the lines of its particular duty.

As noted above, when the instructional materials, the Survey and other teaching services are well progressed

and widely known, the Foundation will extend its work along lines of adult education into communities, and will also assist the world of commerce by bringing its resources in learning to bear on the peculiar educational needs of industry which have arisen through mass-production. In these activities the Foundation stands ready to co-operate with every major institution serving the country in ways parallel to its own course.

VII *How the Individual Can Help*

The times being as they are, and the work of the Foundation being urgent, the question may be raised: How can the individual assist to promote this work?

The readers of MAIN CURRENTS will be kept in touch with the developments. Subscriptions are solicited, especially to institutional libraries. It is therefore suggested that for the time being *subscriptions* be made business of first importance. In the case of college libraries, a simple request may not be enough, for though some librarians may see the immediate and urgent nature of this work, to others it may appear to be only of general philosophical import. The department head or other responsible faculty member making the request for a library subscription would assist us by seeing the library subscription actually put through. Questions from Librarians in a position to subscribe on their own initiative will, of course, be welcome.

Individual subscriptions and gift subscriptions are also useful extensions, provided the recipient has an active interest in the purposes of the journal.

Friends of this work also serve effectively by making its existence known to editors of other journals, inviting announcements of the Foundation, and suggesting exchanges to editors. It should be evident that the Foundation staff must eventually sift systematically the chief learned journals, not in imitation of the Abstracts published in various fields, but with no less comprehensiveness reporting conceptual developments, or advances of general meaning to thought. Hence the friendliest relations with sister journals is important. In many learned journals the conceptual needs of our times are now frequently reflected. These effects will have firmer outlines as the work of the Foundation expands.

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FIELD THEORY IN BIOLOGY

H. S. Burr

The article by H. S. Burr, of the Yale University School of Medicine, *Field Theory in Biology*, which we are privileged to reprint in full below, from *Scientific Monthly*, March, 1947, is based on a paper presented at a symposium on The Philosophy of Biophysics which was part of the annual meeting of the American Association for the Advancement of Science at St. Louis in April 1946.

It is highly significant that this symposium was presented before a joint session of Section L of the A.A.A.S. and the American Philosophical Association, for it demonstrates the increasing interest and importance of the whole, and relations within the whole, to philosophers. The over-all purpose of the symposium, which consisted of three papers, was to consider the application of two physical ideas, those of particle and of field, in their relation to biology and biological research. These ideas, and the techniques which derive from them, originated in physics; what is significant is first their validity in the biological field, and second, their adaptation to usefulness in the domain of the living. Indeed we may say that the tendency to relate concepts in varying fields now runs throughout modern science. Applications of space-time theories, field equations, concepts common to electromagnetism and gravitation have been extended through biology into psychology and psycho-somatics. This general compulsion towards unification, towards some comprehension of what constitutes the totality of life and its environment, is moreover apparent in the prevailing social and historical and even economic pressure towards one world. From this correlation of integrating factors, there emerges the hope and expectation that we shall soon have a greater conceptual understanding of the basic principles which underlie all phenomena: energy, life, and self-consciousness.

Particle physics is concerned primarily with the study of energy and the atomic agents of energy, that is, the positron, the electron, the proton and the neutron. The biologist who uses the approach of particle physics studies the structures and functions of living things in terms of such physical particles, their aggregates and their interactions with each other. In his contribution to the symposium, *The Particle Physics Approach to Biology*, Raymond E. Zirkle of the Institute of Radiobiology and Biophysics, the University of Chicago, discusses the usefulness of this atomistic point of view to the biologist. First, it offers him the simplification of explaining all the activities of organisms in terms of the ultimate particles, thus reducing the consideration of an extremely large number of molecular species to the potentialities determined by the constituent atoms, in turn determined by the subatomic particles. The particle biologist regards the macroscopic properties of an organism, such as gross anatomy, symmetry and gradients of various sorts, as derivatives of particle properties. Thus particle physics concepts lead the biologist to think about biological phenomena in potentially very simple, basic and ultimate terms.

Another great advantage to the biologist is the wealth of techniques offered by particle physics for attack on biological problems, which include all the devices made possible by the properties of the electron: the vacuum tube, the X-ray, the electron microscope and so on. These techniques have made possible the use of ionizing particles in various ways, for example, to produce mutations in applied biology, the use of radiotherapy in medicine, and the recent applicability to biology of the technique of isotope tracing, which makes it possible to distinguish certain previously untracable elements present in animal cells. But in spite of these contributions, progress in solving morphological problems, and those involving the selection and adaptation of organisms as a whole, is very slow by particle reasoning alone.

Following Burr's Field Theory contribution to the biophysics symposium, Henry Margenau of the Department of Physics at Yale, discussed both particle and field concepts as related in biology and physics. He pointed out that particle techniques, which are based on what is often called mechanistic reasoning, cannot solve the ultimate riddle of biological organization. For the biochemist has to deal with peculiarly persistent aberrations, such as vitalism, entelechies and biological fields, which do not readily fall within precise definitions. Yet adherents of the particle view have not always reconciled themselves to field theories. The electric fields described by Burr, however, are much more acceptable, since matter itself is known to contain electrified particles which generate or lie within fields, and hence his theory may well resolve the differences between the two views.

Dr. Margenau makes his contribution towards such a resolution by describing the outcome of the particle vs. field antithesis in the modern electromagnetic theory in physics. For many years the doctrine of the particle structure of matter, formed upon Newton's discoveries, held the forefront of the physical stage. Gradually however, physicists edged away from this view and eventually arrived at the other extreme, as embodied in Maxwell's theory of the structure of the electromagnetic field, which left no room for particles. Certain failures in the application of this hypothesis, finally led Lorentz to propose the electron theory of electrodynamics, which holds that the properties of particles are not an immediate consequence of the structure of the field (as Maxwell held), and that a special hypothesis is necessary to account for the motion of particles within the field. In other words, both particles and fields are conceded an important place in physics. In Dr. Margenau's delightful phrase, "If Newton populated the world with hard peas, and Maxwell thought of it as clear soup, Lorentz has converted it into pea soup."

One of the most fascinating conclusions that emerge from Burr's study is that an electromagnetic structure precisely parallels the organization and design of living things; that this field, whose ultimate origin is as yet

unknown, dominates the chemical and physical properties of the organism. Measurements of the potential even make possible prediction of future growth. Thus the energetic takes precedence over the mechanical in the life process, and it is obvious that the organism can no longer be considered merely the end result of the characteristics of its parts. Margenau points out a recent development in physics which in a sense complements this idea. The exclusion principle of Pauli, which requires a certain symmetry of the states of a complex system, is non-mechanistic in the same sense that it does not allow the properties of the entire complex to be derived from the properties of its parts. It shows that no two elementary particles can be in identical states. When a second electron is added to the nucleus of a hydrogen atom, for instance, to form a helium atom, its motion is no longer fixed by dynamical laws alone, but upon the fact that another electron is present. The effect of the exclusion principle is the same as if one electron "knew" of the presence of the second.

To the lay mind, one conclusion is most apparent from the evidence. Both particle physics and field theories are dealing with the same basic and unifying principle in nature, electrical energy, which, whether operating within the atom itself or without in the electromagnetic field, still determines or reveals the design, symmetry, character, growth pattern and inner harmony of the organism. The real philosophical problem, which concerns the significance of energy as a concept, and its relationship to the life process, is thus strongly identified for us.

Readers of MAIN CURRENTS will perceive at once the radical effect of these studies. The role of biology between the physical sciences in all their aspects and the vital sciences is of key importance to philosophy and to the study of man. It is in essence the link between the mechanical energetic and the living energetic. Our understanding of the mechanics of atomic behavior have led to a much fuller comprehension of the operations of energy. We can be hopeful, now, that electromagnetic and allied studies in the domain of the living will begin to give us greater insight into the more important problems which involve not only the constitution, the essential quality of energy, but also what life itself may be. Our ignorance of the nature of the vital element has led us in the past to study the living from a mechanistic point of view, thus missing the significance of life as a fundamental parallel to energy.

No real progress can be made in understanding man as a unitive organism until life and energy are thus conceptually understood. Once on such sure philosophical ground, we shall be in a position to seek further for the meaning and source of consciousness as it appears in living organisms and self-consciousness as it characterizes man. Studies in configuration psychology, psycho-somatics and general semantics, as well as the unifying principles in cultural tradition as a whole, demonstrate that consciousness is a self-sustaining principle, appearing with, but not organically dependent upon, the vital elements. If our culture is to move forward into a benign enlightenment, rather than be precipitated into the chaotic disintegration threatened by the dominance of mechanism, respect and interest must be restored to the field which is uniquely human, and consent must be given to the primary importance of that which distinguishes man as man. This appears to be the further significance of Dr. Burr's outstanding inquiry, which here follows in its entirety as reported by him in *Scientific Monthly*. E.B.S.

The study of the development of the central nervous system, using the method of experimental embryology, has done little but confirm the well-known fact that in the brain and spinal cord, with their peripheral connections, is an extraordinarily complex organ system. This very complexity has made the study of the nervous system a fascinating exercise. Much has been learned of the elements which go to make up the intricate arrangements of the parts of the nervous system, but our knowledge is still incomplete. The experimentalists have examined the processes by which development has proceeded from relatively simple primordia to highly organized components. Specific potencies of particular cells have been recognized, and processes by means of which the potencies are realized have been described as organizators, inductors, and the like.

Out of this welter of experimental facts, there has emerged a reaffirmation of the fact, known to all neurologists, that the nervous system is the result of an extraordinarily meticulous and precise design. No matter what part of the nervous system is examined, the preciseness of the design is everywhere evident. Masses of neurone cell bodies are seen to be located in specific regions of the nervous system with great exactness. The nerve fiber processes of these cell bodies connect these nuclear masses over rigidly determined pathways. Variations in these structural relations are virtually unknown, save possibly in some of the minute relationships.

The modern neurologist, standing on the shoulders of many generations of careful investigators, has tended to assume that the design of the nervous system is so well known that, except for minor additions, there is little more to be learned. On the other hand, while the final design seems to be fairly well recognized, there is little information in the literature as to the nature of the forces by means of which this design is realized. A few students have been aware that the design of the nervous system is but a special case of design in the living organism. Many have felt that the solution of the problem or organization in all living things would eventually supply an answer to the origin of design in the nervous system. The history of biology shows that the few attempts made to solve the problem have been unsuccessful. Scientists have been loath to accept the "final cause" of Aristotle, the entelechy of Driesch, or the *élan vital* of Bergson, for these represent qualitative descriptions of events and not objectively measured correlates of them. They have been dismissed as unscientific. Somewhat better were the embryonic fields of the German experimentalists, notably Spemann, or the physiological gradients of Child. These latter also are unsatisfactory, for the nature of the forces involved is not explicit. Many modern experimentalists tend to rely on tropisms, either mechanical or chemical. It is not surprising, therefore, that many years of study

of the nervous system led to the conclusion that the problem must be attacked in a new way. The design of the nervous system is extraordinarily precise. Therefore, the forces which make for that precision must be exceedingly powerful. Moreover, the forces themselves must show interrelationships which control not only local events but also the unfolding of the whole pattern. If this problem is faced squarely the question arises, What kind of forces can be imagined that are capable of bringing about these obvious results? The traditional forces are manifestly inadequate. It would seem, therefore, worth while to turn to a different approach. Design is not unique to living systems but is to be found everywhere in the universe. It is not unreasonable to suppose, therefore, that the same forces which impart design to the material universe might also perform the same function in the living organism.

At this point there appear two different approaches. Many investigators believe that the design of the whole system can be deduced from the complete description of all the entities of which the system is composed. This is the attitude of most biologists who believe that, once the living system is analyzed into its constituent chemicals, the design of the living organism will follow as a consequence. The second point of view, however, maintains that there are relationships between entities not completely derivable from the nature of the entities themselves. It is these relational forces which, in the last analysis, control the directions in which activities move and which, therefore, impart pattern to the arrangement of the entities.

Both of these points of view are implicit in much biological research. The first has, however, dominated the picture to the almost complete exclusion of the second. This is probably due in large part to the fact that the second approach has led largely to the development of unprovable theories. It is at this point that biologists can probably turn to the physicists, for physics tells us that there are in the universe three sets of forces —gravitational, electromagnetic, and nuclear.

Of these, gravitation, although it has its influence on growing things, is not strong enough to establish pattern, and nuclear forces, probably the most powerful known, operate over such exceedingly short distances as to be largely irrelevant to the problem of organization. There remain, then, electromagnetic forces as the determiners of design in the universe. In general, all three sets of forces can be conceived of as definable and measurable aspects of a primary field property of the universe. As such, they lend themselves to experimental analysis and verification.

Electromagnetic forces have been known since the investigations of Faraday demonstrated their existence. The mathematical expansion of the field aspects of these experiments, through the analyses of Maxwell, Larmor, and Lorentz, has led to the identification of matter with electricity. The electromagnetic field, in other words, possesses a vector property which not only establishes the position of all charges within its range, but also gives direction to the movements of the charges. This field, then, has the attributes necessary to establish pattern or design in matter. The importance of the concept has been amply attested by the technological developments of the past hundred years.

Physics, then, has provided a clue to the nature of the forces which impose design on the material universe. But living organisms are also a part of the universe. Unless they are conceived of as special creations outside of the laws governing the rest of the cosmos, subject to the controls of an entelechy, or an *élan vital*, they also must be controlled by electromagnetic fields. Moreover, living beings are made up of the same atoms or charges as are found in nonliving matter. There are no reasons to believe that entities common to both worlds are acted on by different forces. The chemistry of living organisms, for example, differs in no essential way from the chemistry of inert matter, save possibly that the problem is more complex. Moreover, the forces involved in chemical reactions are fundamentally electrical, basically the expression of electromagnetic fields.

It is clear, then, that the heart of the problem of the biologist, the forces which impose design on the living organism in general and the nervous system in particular, is identical with that of the physicist who is faced with the origin of design in the material universe. The solution provided by physics, therefore, should be applicable in biology.

If the above position is accepted, a number of conditions must be met. In the first place, a one-to-one correspondence between the pattern of the electromagnetic fields and the organic form of the living organism should exist. For example, one of the characteristics of living things is symmetry, either radial or bilateral. To be sure, this property is not universal. There are forms of life without it. Nevertheless, it is widely found. The proposal made above would demand a significant, measurable relationship between field and symmetry. There should be a correspondence between an axis of the field and that longitudinal axis which is characteristic of the nervous system of the vertebrate.

In the second place, some method of measuring the electromagnetic fields must be available. In the physical world one property of such fields may be determined by establishing points between which there are steady-state potential differences. Such information does not, of course, identify the sources and sinks of the field, but it does provide an important measure of the relationship between the charges. Knowing the sources and sinks, Maxwell's equations make it possible to define the field and its potential gradients. Knowing the potential gradients, the field can be described without giving specific knowledge of the location of the sources and sinks.

Finally, there must be available a technique by means of which true potential differences can be determined. This condition must be attained through the design of a measuring device that is relatively independent of changing resistance and therefore of changing current flow. Only thus can separation of the dependent variables of Ohm's law be achieved. Only thus can an important measure of electromagnetic fields be made accurately.

But can these conditions be met in the living world? Fortunately, they can, for it has been known for more than 100 years that living systems possess many electrical attributes. That these electrical phenomena are important

has been adequately attested by the development of the electroencephalograph, the electrocardiograph, and many electrometric techniques applied to biological problems. Furthermore, there have been many scattered evidences of the importance of these electrical manifestations in other aspects of the living system. Witness particularly the brilliant pioneer studies of Lund on some of the vital processes of such simple organisms as Obelia and such complex mechanisms as the Douglas fir.

So many signs of electrical activity have been found and utilized that it ought to be possible to relate them to each other under a single assumption. This can be accomplished, first, through adequate theory; second, through logical consequences of that theory; and, third, through techniques for testing the predictions in the laboratory.

Let us assume that electrical phenomena are constant concomitants of the living organism. It should then be possible to determine the existence of potential differences. By definition, such potential differences constitute a field. Can it then be shown that the pattern of these potential differences is correlated with the organic pattern of the living system?

What does this mean? It means, as Northrop and I have suggested, that four questions must be put to nature:

1. Do steady-state potential differences exist in living things?
2. Are they chaotic or do they exhibit a pattern?
3. Does the pattern of the electromagnetic field so measured correlate with the pattern of organic form?
4. And, finally, does the field so determined control the design of the living system in the same way that such fields control design in the material world?

It is clear from the above that the following assumption can be made. Electromagnetic fields determine the pattern of organization in biological systems. The logical consequences of such an assumption demand that these fields be measured with certainty, that they exhibit patterns which correlate with patterns of organic form, and that they maintain a certain constancy throughout the complex flux of chemical reactions accompanying growth and the living process. Local short-time changes in the field might be expected to accompany biological activity of various kinds and therefore yield valuable data about specific biological events. It seems to us, therefore, on the basis of all the evidence obtainable, that the application of the field theory of physics to the basic biological problem might yield interesting and significant results.

The past 15 years have been spent in investigations of the possibilities above-stated. At the outset the development of an improved and simplified technique was necessary. With the help of Dr. Cecil Lane of the Physics Department of Yale University, and of Dr. L. F. Nims, a physical chemist, in the Department of Physiology, a procedure was evolved which has made it possible for us to answer many questions. Contact with a living system is made through nonpolarizing reversible silver-silver chloride electrodes in salt solution in approximate ionic equilibrium with the solutions of the system being measured. The difference in potential between any two points with which the electrodes were in contact was measured by a vacuum tube bridge, the input impedance of which was 10 megohms. The high input impedance made the measurement of voltage difference independent of resistance change. With this instrument it has been possible to measure potential differences in the microvolt range. The instrument is sufficiently free from drift so that continuous measurements with suitable apparatus can be made over a long period of time. Finally, the procedure has made it possible to study a living system without interfering with its integrity. A very large part of experimental biological research has involved cutting living systems into ever smaller pieces. This destroys at the outset one of the unique properties of living organisms, their unity. It would take too long to present here all the evidence which has accumulated, but a few of the more important aspects may be interesting.

At the outset, it was obvious that there were in general two types of experiments that could be performed. Since the technique made it possible to measure biological systems from a somewhat new standpoint, a great many of the observations were exploratory. The selection of the particular experiment to be performed was largely determined by circumstances. This resulted in studies of many living systems, ranging from bacteria to man. Interesting and important as these seem to be, the more important objective was the relationship between field theory as measured by standing potentials and fundamental biological problems, particularly the problem of biological organization. However, every attempt was made to plan the experiments so that they might give an answer to the four basic questions mentioned above.

The first of these asks if these standing potentials are to be found everywhere in living systems. The answer is, unequivocally, Yes. In every experiment in which measurements were made on living systems in both plants and animals, reproducible standing potentials were found. They were not invariant, but the variation was nearly always within narrow limits. This is not surprising since a living system is a dynamic mechanism in constant activity, and, hence, some degree of variability might be expected. Nevertheless, in general, the measurements were astonishingly constant.

With regard to the second question—Is there pattern in the potential differences?—the evidence was no less clear. Characteristic patterns of potential differences were found in most of the laboratory animals and in man. In the latter instance, the right side of the body was almost uniformly positive to the left side by several millivolts. In something less than 10 percent of the instances this polarity was reversed. Moreover, in any one individual, potentials measured from day to day, over many weeks and months, showed a definite tendency to remain within very restricted limits. Since the technique makes it possible to study the individual without interfering with normal functioning, many artifacts which might be expected to accompany fragmentation of the living system were avoided. Incidentally, the positive polarity of the right side of the body bears no discernible relation to handedness.

Differences between the sexes were also noted. Early in the study it was observed that there were marked

increases in the potential difference between the right and left side of the body in women, recurring at approximately monthly intervals. This observation led to a more precise analysis of these potentials, and evidence was collected on both animals and women pointing to the probability that this significant change in standing potential was associated with the phenomenon of ovulation. This was an interesting and unexpected consequence of the theory which still requires additional investigation.

Turning now to more fundamental aspects of the consequences of the theory, a characteristic of living systems is their capacity for growth. It was necessary, therefore, to determine whether or not these standing potentials change during the growing process. Corn seed, Obelia, salamanders, and mice were explored, and everywhere it was found that during the process of growth and development the standing potentials steadily increased in magnitude to an asymptote. The pattern of these potentials, however, showed only minor variations. In the salamander egg, for example, potential differences between any two parts appear, but with low magnitudes. During the early stages of cell division and the formation of the blastula and gastrula, there is a steady rise in potential, accelerating with time. This continues with increasing rapidity until the free-swimming larval stage is reached, when potential differences along the long axis of the larva reach a value of 6 or 7 millivolts. The studies on mice reveal that a similar rise in potential occurred in the first third of the animal's life, leveled off during the middle third, and tended to decrease during the last third. During the phases of early differentiation in corn roots and in the developing salamander egg considerable variability in the stability of the potentials was noted. This suggests that the process of differentiation by itself involves a good deal of biological activity as reflected in potential measurements. It was during these studies of growth that the first real evidence of the existence of field properties was noted.

In the experiments on aquatic animals the technique was so arranged that, once the electrodes were in contact with the animal, the stage on which the animal was placed could be lowered away from the electrodes. The animal was then reversed end for end and raised in contact with the electrodes. This gave a check on the validity of the measurement. Quite promptly it was noted that instead of the potential difference dropping to zero the moment the animals lost contact with the electrodes, a voltage difference could still be read, even though 1.5 to 2 millimeters marked the space between the electrodes and the animal. This means, of course, that there must have been voltage differences in the surrounding solution. Such potential differences are not present when the animal is removed from its aquatic environment. The rate of decline of the potential difference, as the distance increases, is an exponential one. The presence of this phenomenon could be due only to the existence in the living system of a field. At first glance it is somewhat extraordinary that an animal in fresh water or in salt solution can maintain this potential without exhaustion. In spite of the presence of an external shunt, the voltage is not only maintained but increases with time.

At one stage in the development of the salamander embryo, actively beating cilia keep the animal in constant rotation within the gelatinous capsule. If electrodes are forced through the capsule, so that they approach the surface of the contained embryo, regular and rhythmic reversals of potential difference can be recognized as the embryo revolves. Because the potentials at this stage are low, an experiment was performed and photographed in which an older animal was mechanically revolved beneath two electrodes. The potential swings were recorded on an ink-writing galvanometer. Under these conditions the revolving salamander produced an electrical output of alternating character very similar to the output of an ordinary generator, save only in magnitude and frequency. Again this phenomenon could not have been recorded if there had not been in the animal a characteristic field.

The third question was, Is there a correspondence between the pattern of potential differences and organic form? The answer to this problem was sought through a study of the electrical characteristics of embryos of both animals and plants. Again the results indicated a close relationship between the measured potential pattern and the developing organism.

The single-cell egg of the frog and the salamander were explored electrically. Structurally these eggs are radially symmetrical systems, but electrically they are not. Measurements made between the upper pole of the egg and four equally placed points on the equator showed that invariably there was one point which showed a greater voltage drop than any of the others. This point could be marked and the subsequent development of the egg watched. In every instance, the head end of the embryo developed at the point of greatest potential difference. This electrical asymmetry was present before the egg was fertilized and, so far as the present studies go, showed no change following fertilization. Here, then, is evidence of the existence of an electrical pattern, present before the appearance of any formed structures, carrying on through fertilization and cell division up to the formation of a definite nervous system. The axis of the embryo coincides with the axis of the electrical field. There is, in other words, an electrical pattern, present through the early phases of development in spite of innumerable chemical reactions and definitely related to the pattern of organization of the nervous system. The constancy of this field pattern raises innumerable problems yet to be solved. Since the electrical pattern is present before and after fertilization, there is indicated a positive relationship of the field to the design of the living system and to its genetic constitution.

Because the problem of form in plants is somewhat simpler than it is in animals, a study was made of the correlation between electrical patterns and form in plant embryos. Cucurbits were chosen because the important studies of Sinnott have provided a structural basis for an examination of any such relationships. Three inbred lines of *Cucurbita pepo* were used. One developed elongate fruits, one round, and one flat. Measurements of the potential differences were made along the axial and equatorial diameters of young ovaries and developing fruits of these three races differing markedly in shape. It was found that the magnitude of the potential differences bears little relationship to the absolute size of the

embryo, but there was a high positive correlation between the ratios of the electrical differences and the ratio of the dimensions. Here, then, is another evidence of a significant relationship between electrical pattern and form.

The studies of the electrical properties of plant embryos were sufficiently successful to warrant the extension of the measurements to plant seeds. For, if this field is as fundamental as we have assumed, it would follow logically that there would be significant correlations of electrical patterns with aspects of the living system other than form. Furthermore, since the earlier studies on growth had shown a steadily increasing potential during the growing period, it was thought that there might be a significant relationship between the initial measured potential and the growth capacity of the seed. There have been innumerable studies on corn with a good deal of evidence regarding growth rates and their relationship to genetic background. There was, therefore, a possibility of the discovery of further relationships between potential and genetic constitution. Exploration of these problems was attempted with the cooperation of W. R. Singleton, of the Connecticut Agricultural Experiment Station. The corn seed used were from strains which had been under study for some time. These differed considerably in genetic constitution and more particularly in the degree of hybrid vigor resulting from crosses between them. Four inbred strains were used and three hybrids. The potential measurements were made between the germinal and the microphylar ends of the seed. A statistical analysis of the results showed significant differences in the mean potentials obtained from each strain. One of the strains was a single gene mutant from the parent stock; yet the potential in the parent stock was more than four times that of the single gene mutant. It is surprising that a single gene change should be correlated with such a large change in potential. The potential differences in the hybrids showed a gradation closely correlated with the measurements of hybrid vigor determined by field studies. One of the hybrids known as "Marcross" is an outstanding early season hybrid. The seed from this strain had the highest potentials of any of the hybrids. Likewise, in the pure strains there was a positive correlation between the results of field studies on yields and the measured standing potentials of the seed. In other words, the potential differences measured were such as to make possible a prediction of the subsequent history of the seed when planted in the field. These studies made it clear that there is a significant relationship between the measurable electrical properties of corn and the genetic constitution of the seed, as well as its hybrid vigor. Here we have the rather extraordinary finding that accurate potential measurements make it possible to predict the subsequent growth history of individual seeds.

Since the above study was dependent in large measure on field data collected before the potential differences were determined, a large number of seeds were measured, placing them in high, medium, and low potential groups. These were then planted under controlled conditions in the field, and their growth and yield studied. Oliver E. Nelson, Jr., Eastern States Fellow at the Connecticut Agricultural Experiment Station, realizing the possibilities inherent in such a study, agreed to carry out the field experiments. During the past three years many measurements were made on corn and the seed allocated to the three groups of potential differences. Each group was then planted in the field under controlled conditions, and at weekly intervals a variety of growth measurements were made. The first summer was, unfortunately, unseasonably dry, with consequent interference with the growth processes in the plants. In spite of the adverse conditions, the potential seed developed plants which grew faster, reaching an ultimately greater height, and produced heavier ears than did the low-potential seed. With only one exception, the medium-potential seed produced plants intermediate between the two extremes. The seed from these plants were collected, replanted the second summer, and yielded the same results in more striking form. Seed from these plants were then measured, and the plants from high-potential seed were found to have developed seed with high potential.

In addition to the above results, there was clear-cut evidence that the magnitude of the standing potential was related not only to growth capacity or hybrid vigor, but also to the genetic constitution. More work of this sort needs to be done, but results already achieved provide a promising lead to a quantitative solution of at least two basic plant problems—genetic constitution and heterosis.

One of the logical consequences of the field theory underlying all these experiments demands that variation in the electrical environment should be reflected in small but detectable alterations in the potential differences. It has been shown by Professor Harlan T. Stetson, of the Cosmic Terrestrial Research Laboratory of the Massachusetts Institute of Technology, that changes in the ionosphere significantly affect radio reception.

It seemed worth while, therefore, to design an experiment which would provide continuous records of the changing potential in a living system. If, at the same time, careful records were kept of changing temperature, humidity, barometer, sunspots, and possibly cosmic rays, it might be possible to detect whether or not correlates between any of these variables could be found. A growing tree was chosen for obvious reasons, and quite complete records have been obtained from three varieties of trees—maple, elm, and oak—in Lyme, Conn., and in New Haven. No correlates were found among temperature, barometer, and humidity of either the magnitude of the standing potential or its polarity. Daily variations of a diurnal sort were found, as were also seasonal changes. Plots of all the data collected suggested the presence of at least three sets of cycles—two 6-month cycles; three 4-month cycles; and a shorter cycle of approximately 28 days, which seemed to be most closely related to the phases of the moon. The data exhibit the remarkable stability of these standing potentials, which, nevertheless, are subject to definite variations. It is difficult, however, to decide whether the determinations are endogenous or exogenous. If they are exogenous, they certainly are not due to local variations in external environment. The possible correlation with phases of the moon suggests a

relationship between the local fields of the tree and the general electrical characteristics of the troposphere. The nature of the endogenous forces which might be present, producing variations in the electrical gradients, is quite unknown. It is hoped that by continuing this study over a period of at least ten years, covering approximately one complete cosmic ray cycle, further evidence may be obtained.

Evidence in the literature of experimental biology points to the importance of the electrical properties of living systems. Furthermore, the data suggest that these electrical attributes are of such widespread occurrence that, in all probability, they are of more fundamental significance than has been generally assumed. It seemed worth while, therefore, to study living organisms from the point of view that the electrical manifestations are a sign of a fundamental electrodynamic field. Such a hypothesis demands that in the laboratory there should be one-to-one epistemic correlation between the logical consequences and experimentally verifiable observations. The studies reported above exhibit such a relationship and, therefore, imply that the basic theory has merit. Moreover, since the theory derives from fundamental field theory in physics, it makes it possible to subsume under one heading the nature of the forces which impart design to living, as well as nonliving systems.

BOOKS & RECENT ITEMS

Spiritual Values In The Elementary School

The recent publication of *Spiritual Values in the Elementary School* (Twenty Sixth Yearbook of the Department of Elementary School Principals of the National Education Association, 1201 Sixteenth St., Washington, D.C., September 1947, $3.00) marks the end and the beginning of an era in the elementary school. For about fifty years the public schools had reacted to the earlier teaching of religion as theory of living, by expunging its values from the curriculum. The secularity of the public school program in those decades proceeded through neglect into contempt and even into polemic materialism. Suddenly, however, the elementary school woke up to the fact that it had a new program, which had been rising gradually out of the fathering of Francis W. Parker and many who have followed in his spirit. The elementary school had a vital program of actual living based upon a curriculum of doing instead of only dreaming. At last there has come the day of acclaim when it has been discovered that "better living" is essentially spiritual living.

This volume is full of descriptions of superior school practice which are well worthy of study and imitation by school workers. Here it is proclaimed that spiritual living is a seven day affair, not a thing a part. It can live in such children's activities as making a colored frieze of a fleet of ships, enjoying nature and living creatures, solving problems in the school council and on the playground. It is being revealed to school people that nothing brings one more quickly to a realization of spiritual meaning that actually beginning to live well in individual and group life. This understanding has yet to come to our colleges and other institutions of higher learning, which are still, for the most part, on the doctrinal level. When they move into the conduct area, as they are about to do, where personal responsibility and creative activity are regular parts of student life, the revelation which has already come to the elementary school will come to them also.

A. Gordon Melvin

Point And Line To Plane

The Solomon R. Guggenheim Foundation has published an English translation of Kandinsky's ***Punkt und Linie zu Fläche,*** done by Howard Dearstyne and Hilla Rebay. The volume is handsomely produced, and opulently illustrated, and forms a valuable record of the thoughts of one of the most philosophical of men, influential as a working artist primarily, not merely as a theorist, in the modern art field. He is generously represented at the Museum of Non-Objective Painting, and a choice example of his work is reproduced in colour in this present volume, by Little Dream in Red, which readers of Main Currents will find upon the cover of our January, 1947 issue.

The present translation includes, however, the scores of studies of forms created by points and line on planes (hence the title), and Kandinsky's interpretations of his own feelings and thoughts as to these relationships. As the movement represented by the non-objective painters and sculptors takes form through the years, the present account of a pioneer will have increasing value.

In this case what can one mean by the phrase, "takes form?" Is it not the central doctrine of the movement that it is independent of principle? Is it not true that the movement is the expression in art of absolute relativity among philosophers? Time must answer that question, and he would be foolish who presumed to anticipate, but this much can be said: Relativity as a philosophy is not the champion of the random and chance, if by relativity we refer to the work of Einstein. The attempt to assimilate relativity with neo-Darwinian chaos must be resisted, as a mere historical phenomenon of the effect of an old doctrine on a new one. Relativity does not pronounce upon the question of the primacy of order over disorder or the reverse. It declares the co-entry of the space-time matrix (the whole or the source) with the energy-dynamism of nature, into the structure of the world. If it proves that the space-time matrix is charged with order and has the role of causal source, then that must be accepted. It is premature to decide.

This fluid circumstance of today is what makes the freedom of the artist important. He can feel his way to new experiences which cannot be reached or justified as yet by reason. But this is no occasion for him to prejudge the issue as a whole. He cannot supplant the philosopher. Kandinsky is too wise to attempt to do so. He is the force he is because he declares his artistic freedom, and expresses himself as he is. A long time may have to elapse before the new materials about nature and man make it possible to determine what really is the working truth of the relation of beauty and order to creativity and freedom. Every great question, such as the doctrine of entropy, will enter into the decision.

And so will the work of Kandinsky. The student of over-all philosophy has occasion to be grateful to the Solomon R. Guggenheim Foundation workers for having so lovingly and generously made Kandinsky's deepest musings available.

F. L. K.

The Ever-Present Whole

The summarized conclusion of this discussion is that geometry, as studied through the ages, is one chapter of the doctrine of Pattern; and that Pattern, as known to finite discrimination, is a partial disclosure with an essential relevance to the background of the Universe. Also the term "Geometry" refers to a genus of patterns; and this genus includes a variety of species . . .

Even in arithmetic you cannot get rid of a sub-conscious reference to the unbounded universe. You are abstracting details from a totality, and are imposing limitations on your abstraction. Remember that a refusal to think does not imply the non-existence of entities for thought. Our conscious thought is an abstraction of entities from the background of existence. Thought is one form of emphasis . . .

What is the fundamental notion at the base of Algebra? It is the notion of *"Any* example of a given sort, in abstraction from some particular exemplification of the example or of the sort."

The first animal on this Earth, who even for a moment entertained this notion, was the first rational creature. You can observe animals choosing between *this thing* or *that thing*. But animal intelligence requires concrete exemplification. Human intelligence can conceive of a type of things in abstraction from exemplification. The most obvious disclosures of this characteristic of humanity are mathematical concepts and ideals of the Good — ideals which stretch beyond any immediate realization . . .

We cannot understand the flux which constitutes our human experience unless we realize that it is raised above the futility of infinitude by various successive types of modes of emphasis which generate the active energy of a finite assemblage. The superstitious awe of infinitude has been the bane of philosophy. The infinitude has no properties. All value is the gift of finitude which is necessary condition for activity. Also activity means the origination of patterns of assemblage, and mathematics is the study of pattern. Here we find the essential clue which relates mathematics to the study of the good, and the study of the bad.

You will notice that earlier in this essay we have emphasized that there are no self-existent finite entities. The finite essentially refers to an unbounded background. We have now arrived at the converse doctrine, namely, that infinitude in itself is meaningless and valueless. It acquires meaning and value by its embodiment of finite entities. Apart from the finite, the infinite is devoid of meaning and cannot be distinguished from nonentity. The notion of the essential relatedness of all things is the primary step in understanding how finite entities require the unbounded universe, and how the universe acquires meaning and value by reason of its embodiment of the activity of finitude . . .

The notion of the importance of pattern is as old as civilization. Every art is founded on the study of pattern. Also the cohesion of social systems depends on the maintenance of patterns of behavior; and advances in civilization depend on the fortunate modification of such behavior patterns. Thus the infusion of pattern into natural occurrences, and the stability of such patterns, and the modification of such patterns, is the necessary condition for the realization of the Good.

Mathematics is the most powerful technique for the understanding of pattern, and for the analysis of the relationships of patterns . . .

Each entity possesses essentially an individual character, and also is essentially a terminal of relationship, potential or actual. Some of the factors of individual character enter into the relationships, and conversely the relationships enter into the character. In other words, no entity can be considered in abstraction from the universe, and no entity can be divested of its own individuality. The traditional logic over-stressed the notion of individual character. The notion of "any" frees us from individual character: but there is no entity which is merely "any." Thus when algebra is applied, factors beyond algebraic thought are relevant to the total situation . . .

The notion of pattern emphasizes the relativity of existence, namely, how things are connected. But the things thus connected are entities in themselves. Each entity in a pattern enters into other patterns, and retains its own individuality in this variety of existence. The crux of philosophy is to retain the balance between the individuality of existence and the relativity of existence. Also each individual entity in one pattern may be capable of analysis, so as to display itself as the unity of achieved pattern. The point that I am emphasizing is the function of pattern in the production of Good or Evil in the finite unit of feeling which embraces the enjoyment of that pattern. Also the essential characterization of mathematics is the study of pattern in abstraction from the particulars which are patterned . . . (A. N. Whitehead, in *Mathematics and the Good,* a lecture delivered in Harvard University, Dec. 15, 1939, quoted by Paul Arthur Schilpp, editor, *The Philosophy of Alfred North Whitehead,* Northwestern University, 1941. The Library of Living Philosophers Volume III.)

THE CURRENT COLLEGE CONTROVERSY

Stephen M. Corey

In the March, 1947 issue of the Bulletin of the Association of American Colleges, pages 175 to 188, is found the full report of an address delivered by Professor Stephen M. Corey of the University of Chicago, before the Association of Northern Baptist Colleges in Boston, on January 16th last. Under the heading "The Current College Controversy," Professor Corey provides a valuable and widely read review of the present situation which has been developing between two large groups of educators. Could these people be brought together readily for conference, they might soon not be extremities of a central position. Discussion at long range is actually shaping them up needlessly into two schools. As MAIN CURRENTS is devoted to the proposition that a valid study of the nature of man and the structure of the universe in contemporary terms would solve a great many classical problems, and thus unite the most active forces in education in a common program, Dr. Corey's remarks should have a special value to our readers.

After identifying and briefly discussing administrative and policy problems which arise from overcrowding, government spending on education, and the like, Mr. Corey continues:

Attention will eventually shift back to inquiries into the worth of the experiences students are having in college. Anyone who has read critically the books dealing with this subject which have appeared in the last ten years cannot help but be impressed by the "battle lines" that have already been formed. A number of these books —including titles such as *The Chicago College Plan* by Brumbaugh and Boucher; *A College Program in Action* by the Committee on Plans of Columbia College; *General Education in a Free Society,* the Report of the Harvard Committee; *Liberal Education Re-examined* by Greene and others; *The Higher Learning in America* and *Education for Freedom* by Hutchins; and *Liberal Education* by Van Doren—contend that the college fulfills best its function of providing good general education when it transmits, or teaches systematically, the best of the cultural heritage. According to these authors the responsibility of any college faculty is first to decide what it is all students should learn in order to be good citizens, and then to organize this "subject matter" carefully into a sequence of courses which every student "takes."

The interest of such colleges centers on knowledge that must be acquired. Mr. Hutchins has expressed this point of view as follows: "Education implies teaching. Teaching implies knowledge. Knowledge is truth. Truth is everywhere the same. Hence, education should be everywhere the same" (Robert M. Hutchins, *The Higher Learning in America,* 1936, p. 66). Mr. Hutchins then states that this general education which should be everywhere the same for everyone should include "a course of study consisting of the greatest books of the Western World, and the arts of reading, writing, thinking, speaking, together with mathematics, the best exemplar of the process of human reason" (p. 5).

Other publications about general education at the collegiate level—books such as the Muskingum College faculty statement, *A College Looks at Its Program; The Outcomes of General Education* by Ekert; *Vitalizing Liberal Education* by Henderson; *Emotional Factors in Learning* by Murphy and Ladd; *The Dynamics of Learning* by Cantor; *Building a Curriculum for General Education* by Spafford; *Those We Teach* by Williams; and Sidney Hook's *Education for Modern Man,* argue that the college program should be specifically appropriate to the needs of individual students. This requires a flexible, adaptable curriculum with various students learning various lessons at various times.

While faculty members in institutions of this latter sort are primarily interested in students, they also value books. The Sarah Lawrence College faculty says, for example: "We share with other teachers in liberal arts colleges the belief that records of human experience of the past may illuminate confused problems of the present, and that understanding creative work of the past in our own and other cultures is a necessary part of understanding present creative work." These teachers go on to point out that whether or not a student will derive maximum benefit from any of the Great Books or from any other type of literature "depends upon the answers to many questions regarding the ability, maturity, imagination, present problems, and curiosity of the student." (Lois B. Murphy and Henry Ladd, *Emotional Factors in Learning,* p. 6). This attitude means that a college like Sarah Lawrence cannot fulfill its function unless its students are constantly studied. In order to come to some decision about the kind of lessons a certain young person should learn, much must be known both about him as an individual and about the society in which he has lived and will live.

It is likely that during four years students in each of these types of institutions will learn many of the same lessons. The timing of these lesons would be different, however. In one college all of the young people would have the experiences in chorus, so to speak. In the other, the chronological sequence would be highly individualized.

From this point on I will refer to those educators who would accept Mr. Hutchins' point of view as "content centered," and the second group, those who would defend the Sarah Lawrence program as "student centered." Most college programs seem to be mixtures, but there are strong influences at work which tend to make faculty members accept with some enthusiasm one point of view and reject the other.

It is easy to exaggerate the differences between those who support the "content centered" or the "student centered" college. Actually they have much in common. For example, both groups are in general agreement in their descriptions of the type of person they would like to see a college education produce. Their objectives are the same. Mr. Buchannan of St. John's College says that he believes an individual who has been to college should "be able to think clearly and imaginatively—to

distinguish sharply between what he knows and what is merely his opinion. . . . He will have acquired a distaste for the second rate. . . . He will get genuine pleasure from using his mind on difficult problems. He is likely to be humorous; he will certainly not be literal minded. His appetites and emotions will be under his control. . . . He will be eminently practical. He will be concerned to exercise a responsible citizenship. He will cherish freedom for himself and others."

Few would criticize this paragon. A college with concrete evidence that its curriculum produces such virtue does not, of course, exist.

Professor Corey then discusses three more convictions shared by both parties to the college controversy: "their confidence in education;" "the low opinion each group has of the conventional type of college education;" and "the contempt in which each holds the other." The last item stems in the content centered advocates from sensing the drift of educational events at the secondary school level away from them, according to Dr. Corey, who refers to "Education for ALL American Youth," Educational Policies Commission, '44, Washington, D.C., 421 pp. The anxieties of the advocates of the student centered program, he feels, arise from the lack of logical organization of the curriculum they advocate and from their inability to support their arguments from the "classics."

Mr. Corey also lists a number of fundamental differences: 1. "The 'student centered' educator puts great stress upon meeting the specific developmental needs of individuals." "The 'content centered' group argues that individual needs are ephemeral and superficial." 2. "Those who emphasize 'content' place high value upon the importance of an education that is preponderantly verbal." "The 'student centered' faculties agree that reading and other types of verbal activity provide one important method of learning, but they insist that to confine the college curriculum to books to be read and talked about is to fail to take advantage of what is known about the necessity for varied experiences if words are to communicate adequate meanings." 3. "those who argue for systematic transmission of the cultural heritage are, as has been said, more apt to stress the importance of logically organized subject matter and a rational sequence of courses." We quote Mr. Corey again:

The "student centered" faculties believe that the above position confuses two separate questions. One pertains to what there is to be learned, and only scholars have the answer. The second question—what should a particular individual learn at any one time in order to develop satisfactorily as a person—requires not only familiarity with subject matter, but also a penetrating understanding of the individual and a judicious selection of learning experiences that will be most beneficial for him. This does not mean that those who emphasize the importance of student needs belittle organization, but rather that they believe the conventional, logical organization of the curriculum is ineffective.

Those who believe in the "student centered" approach state that highly individualized teaching . . . is precluded in most colleges, not because there are too few faculty members, but because of a traditional and inflexible attitude toward both the curriculum and the role of the teacher. In good colleges there is now at least one teacher to every fifteen students. Experience at the University of Chicago and elsewhere with the so-called "workshop," in which the instruction is individualized and specifically related to the intellectual and personal needs of the student, indicates that a teacher student ratio of one to fifteen is adequate.

As a consequence of their convictions about the curriculum the "content centered" group thinks in terms of "subjects to be learned" and the decision as to what is included in the courses as well as their sequence is a unilateral one in the sense that the students do not participate. The spirit of curriculum construction is authoritarian. The colleges that emphasize the needs of individuals, on the other hand, almost invariably make it possible for the students to take part in planning their own learning activities. It is thought that one of the great potential benefits of a general education is that young men and women will learn how to direct their learning when they are "on their own." They can be given help by staff members who not only know subject matter in the conventional sense, but who also understand young people and the learning process.

Their contrasting views of the learning process represent a fourth difference between the two groups of authors writing about the American college. Those who concentrate on content seem to believe that the human personality develops in terms of several separate functions. They express most concern with intellectual growth and place much confidence in transfer of training.

When it comes actually to developing their curriculum the "content centered" educators are most apt to work by deduction. They begin with their definition of the good citizen and then, through a process of inference, arrive at conclusions as to the type of higher education this good citizen should have. The "student centered" group believes that the only way to find out whether or not a college curriculum is effective is to try it and measure the consequences. If it is insisted that reading the Great Books will result in great citizens, the sensible test of this hypothesis is to have a group of students read the books and then observe what kinds of citizens they become. Their opponents say that this is not an hypothesis to be tested, but a self-evident truth. If the great citizens of the past have recorded their thoughts in the Great Books then it follows that those who read and understand and accept these books will be great citizens.

(To be concluded)